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14. ABSTRACT The program was kicked off on July 26. Project work has been limited to planning, procurement of a partial shipment of alternative membrane material, and the initiation of alternative material and baseline screening. Delay in receipt of materials from Gore has extended subtask 5.1 and 5.2. This delay will not impact overall schedule, as the baseline characterization was focused on first.						
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## **Quarterly Progress Report**

**Project Title:** Improved Round Trip Efficiency for Air Independent Regenerative Fuel Cell Systems

**Project Period:** June 18, 2010 to June 17, 2011

**Date of Report:** September 30th, 2010

**Recipient:** Proton Energy Systems

**Award Number:** N00014-10-C-0369

**Working Partners:** W. L. Gore

**Cost-Sharing Partners:** None

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**Project Objective:**

The purpose of this effort is to investigate advanced membrane materials that enable higher efficiency electrolysis, substantially improving the practical energy density for regenerative fuel cell applications. Additionally, exercisable options in this project will advance the understanding, implementation, and operational testing of the features that enable an RFC to simultaneously be truly air independent and have high energy density.

**Objectives:**

- Define the key membrane attributes that correlate with performance characteristics important for device function such as proton conductivity, ion exchange capacity, nitrogen and water permeation, and visual evaluation of mechanical strength of the membrane in the seal areas of the cell. (Gore and Proton)
- Determine the optimal processing parameters (pretreatment, pressing temperature, time) of these membranes for MEA fabrication. (Proton)
- Define thickness of the membrane required to withstand sealing loads and electrical loads as well as differential pressure. (Proton)
- Define the practical performance limits of these new membranes in terms of operating current, pressure, and temperature. (Proton)
- Based on screening of membrane samples, test a refined list of potential candidates at full-sized MEA scale.

**Background:**

Navy underwater vehicle platforms (UUV, ASDS, SWCS, etc.) are demanding larger and larger energy storage capacities to accommodate longer underwater missions and increased platform power requirements. New energy storage devices with high volumetric energy density for underwater vehicles, both manned and unmanned, are therefore needed, such as regenerative fuel cell (RFC) systems based on proton exchange membrane (PEM) technology. An RFC consists of a fuel cell powerplant, an electrolysis system for recharging the reactants, and reactant storage. These water-based energy storage systems have been shown to perform substantially better than traditional battery systems in areas such as rechargeability, specific energy density, and reliability. Advanced membrane and catalyst materials will enable higher efficiency electrolysis, substantially improving the practical energy density for regenerative fuel cell applications.

From a full proposal to develop an advanced demonstration system, Task 5 was selected for initial study. This task focused on membrane development. The research objectives for Phase 1 of this task were broken into the following separate subtasks:

**Task 5.0: Thinner, Reinforced Membranes:**

***Task 5.1 Alternative Membrane Material Procurement***

The contractor shall procure up to four advanced alternate membrane materials from not more than two membrane suppliers. These samples will be large enough for testing at the 0.03 ft<sup>2</sup> cell size.

***Task 5.2 Alternative Material Screening Tests***

The contractor shall evaluate the advanced alternate membrane materials for strength, fluid permeation, and ionic conductivity using typical Proton procedures. Fluid permeation may be conducted at up to two temperatures and three pressures.

***Task 5.3 Material Treatment Process Optimization***

The contractor shall conduct not more than three process trials with each of two alternative membrane candidates.

***Task 5.4 Catalyst Application Process Optimization***

The contractor shall conduct not more than three process trials with each of two alternative membrane candidates.

***Task 5.5 Feasibility Testing***

The contractor shall evaluate the samples generated from tasks 5.4 using standard Proton procedures for lateral and cross-cell resistance measurements. The best of the three trials for each candidate shall be selected for use in integrated operational testing. Not more than 3 single-cell tests shall be supported for up to 100 hours.

**Status:**

The program was kicked off on July 26. Project work has been limited to planning, procurement of a partial shipment of alternative membrane material, and the initiation of

alternative material and baseline screening. Delay in receipt of materials from Gore has extended subtask 5.1 and 5.2. This delay will not impact overall schedule, as the baseline characterization was focused on first.

#### **Task 5.0: Thinner, Reinforced Membranes**

##### ***Task 5.1 Alternative Membrane Material Procurement***

Procurement of alternative membrane samples has been initiated. A partial shipment from Gore was delivered to begin the screening process. Additionally, some samples from DuPont of an R&D reinforced material have been provided to Proton for evaluation. Baseline material has been received.

##### **Subtask 5.2 Alternative Material Screening Tests**

Characterization of the baseline material has been completed. Gore material in the three (3) different thicknesses has been subjected to all characterization tests, except for bench-top electrochemical performance.

##### **Subtask 5.3 Material Treatment Process Optimization**

Activity has not started.

##### **Subtask 5.4 Catalyst Application Process Optimization**

Activity has not started.

##### **Subtask 5.5 Feasibility Testing**

Activity has not started.

#### **Task 5.0 Project Management and Reporting**

A kickoff meeting was held with both ONR and Proton personnel on July 26, 2010. Formal test plans have been created and milestones set with the project sponsor. Meeting held with DuPont to discuss alternative reinforced membranes for evaluation.

#### **Plans for Next Quarter and Key Issues:**

In the next quarter, work will be completed on the initial screening of the Gore and DuPont materials. It is anticipated that the balance of the Gore order will be fulfilled and all materials will be received, closing out task 5.1 and 5.2. Diffusion measurements will indicate the upper limit for cell operating pressure for a given material.

Parameters for successful processing of membrane samples will be identified. The samples will be evaluated post process to look for deviation against the initial characterization.

**Patents:** None to date.

#### **Publications / Presentations:**

Slides from the ONR kickoff meeting July 26, 2010 have been released internally.

## Task Schedule

Task Number	Project Milestones	Task Completion Date				Progress Notes
		Original Planned	Revised Planned	Actual	Percent Complete	
1	Alternative Membrane Procurement	08/31/10	10/29/10		50%	Partial shipment received for testing. Was enough to begin screening
2	Alternative Membrane Screening	09/30/10	10/15/10		50%	Diffusion and thickness measurements completed.
3	Membrane Treatment Optimization	12/31/10			0%	Not started
4	Catalyst Application Optimization	02/28/11			0%	Not started
5	Feasibility Testing	06/17/11			0%	Not started.
6	Project Management	06/17/11			25%	Detailed internal test plan completed

## Budget Summary

Quarter	From	To	Estimated Billing	Actual Billing
1Q10	06/18/10	9/18/10	\$30,190	\$34,992
2Q10	04/01/10	06/30/10	\$17,500	
3Q10	07/01/10	09/30/10	\$15,824	
4Q10	10/01/10	12/31/10	\$13,424	
		<b>Totals=</b>	<b>\$76,938</b>	<b>\$34,992</b>